THE EFFECTS OF ENTRAINMENT ON STABILITY OF THE MARINE CLOUD LAYERS

Joseph Chi
Department of Mechanical Engineering
University of the District of Columbia
Washington, DC 20008-1174
Phone: (202)274-5047
E-mail: jchi@compuserve.com

Award No. N00014-96-1-0973

LONG TERM GOALS

Goals of this project are to identify physical processes that determine the dynamics of the marine cloud layers and to quantify the roles of turbulence, convection and thermal radiation that play in formation, dissipation and stability of the marine cloud layers.

OBJECTIVES

Our immediate objectives are to advance theoretical models, use efficient numerical schemes and develop computer programs to simulate the marine cloud layers. Comparison of computer results with published field observations will yield insights into the cloud-layers' physical processes.

APPROACH

Attention has been given to include the physical factors: thermal radiation, turbulence scales and convective circulation. Consideration has been given to grid generation, structures of discretization equations and solution algorithms. Computational speed and computer memory sizes have been optimized. Simulation results will be compared with the published observations.

WORK COMPLETED

Second-order turbulence and thermal radiation models were developed by the author (Chi, 1996). In 1997, a large eddy simulation (LES) method has been developed to increase the calculation efficiency. A tridiagonal-matrix algorithm (TDMA) has been developed to solve the resultant large-scale matrix equations in multi dimensions. The model has been used to study the effects of warm-air entrainment at cloud tops on stability of the marine cloud layers.

RESULTS

Fig. 1 shows contours of stream functions of an atmospheric domain with entrainment at the top. The steady-state cloud layer established by simulation at the 40th hour (Chi, 1996) is used as an initial condition in the present computer simulation study of the cloud-layer stability. Contours plotted in Fig. 2 are the initial steady-state potential temperature values, total moisture humidity

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**
4. TITLE AND SUBTITLE **The Effects of Entrainment on Stability of the Marine Cloud Layers**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of the District of Columbia,Department of Mechanical Engineering,Washington,DC,20008-1174**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT	b ABSTRACT	c THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ratio values and liquid moisture humidity values, respectively. Results of transient simulation of the effects of warm air entrainment at the cloud top using these initial conditions are shown in Fig. 3. From snapshots shown in Fig. 3 of the cloud contours at different times (i.e., half, one, five and ten hours) from the start of the simulation run, dissipation of the cloud layer can be observed.

IMPACT

In the previous year, a computer simulation of the air-and-sea boundary layer heat and moisture transfer was made to observe theoretically the growth of marine cloud layers. In 1997, an extension of the theory was made to include the effects of convective entrainment of air at the cloud top on the dynamics of the marine cloud layers. These quantitative results will provide us with theoretical tools to identify processes observed physically in the marine cloud layers.

TRANSITIONS

An article is being considered for presentation at the 1998 ASME Annual Conference as a symposium paper, entitled: “A Large Eddy Simulation Model for the Dynamics of Marine Cloud Layers.”

RELATED PROJECTS

Contacts have been made with the NASA/GSFC in obtaining their satellite data to be analyzed by our computer simulation model for comparison to increase confidence in our theoretical results.

REFERENCES

Chi, J., 1996: The Effects of Turbulent Heat and Moisture Transfer on the Dynamics of Marine Cloud Layers, Proc. ASME Fluids Engineering Summer Meeting, **236**, 227-232, San Diego, CA.

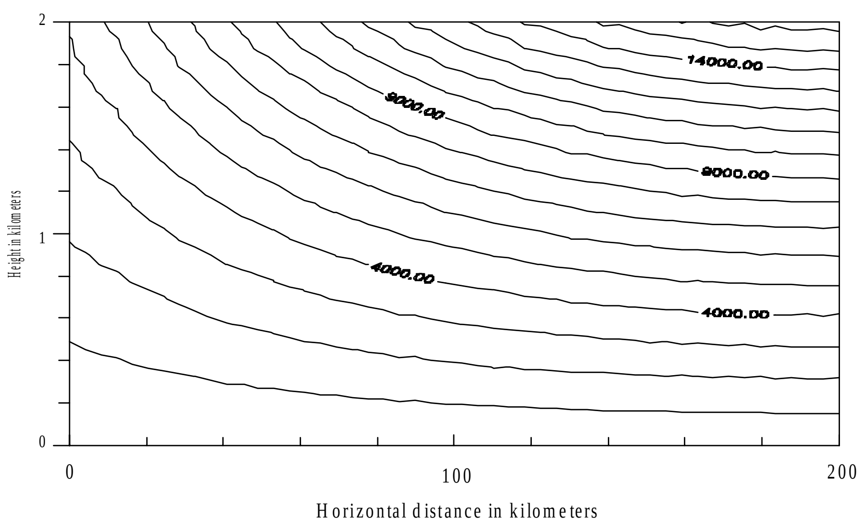

Fig 1: Contours of Stream Functions with Entrainment at the Top

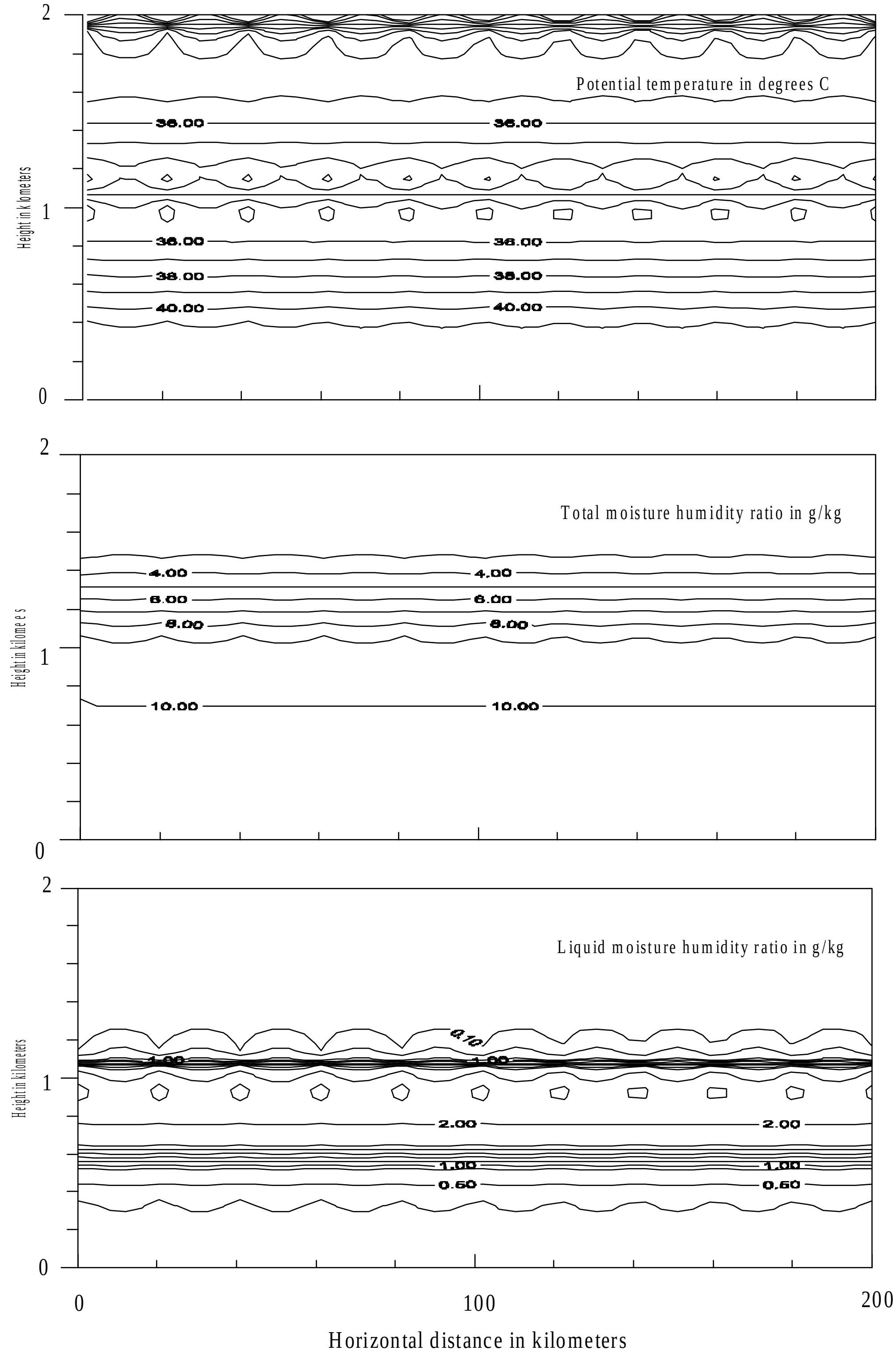

Fig. 2: Initial Steady state at the Zeroth Hour

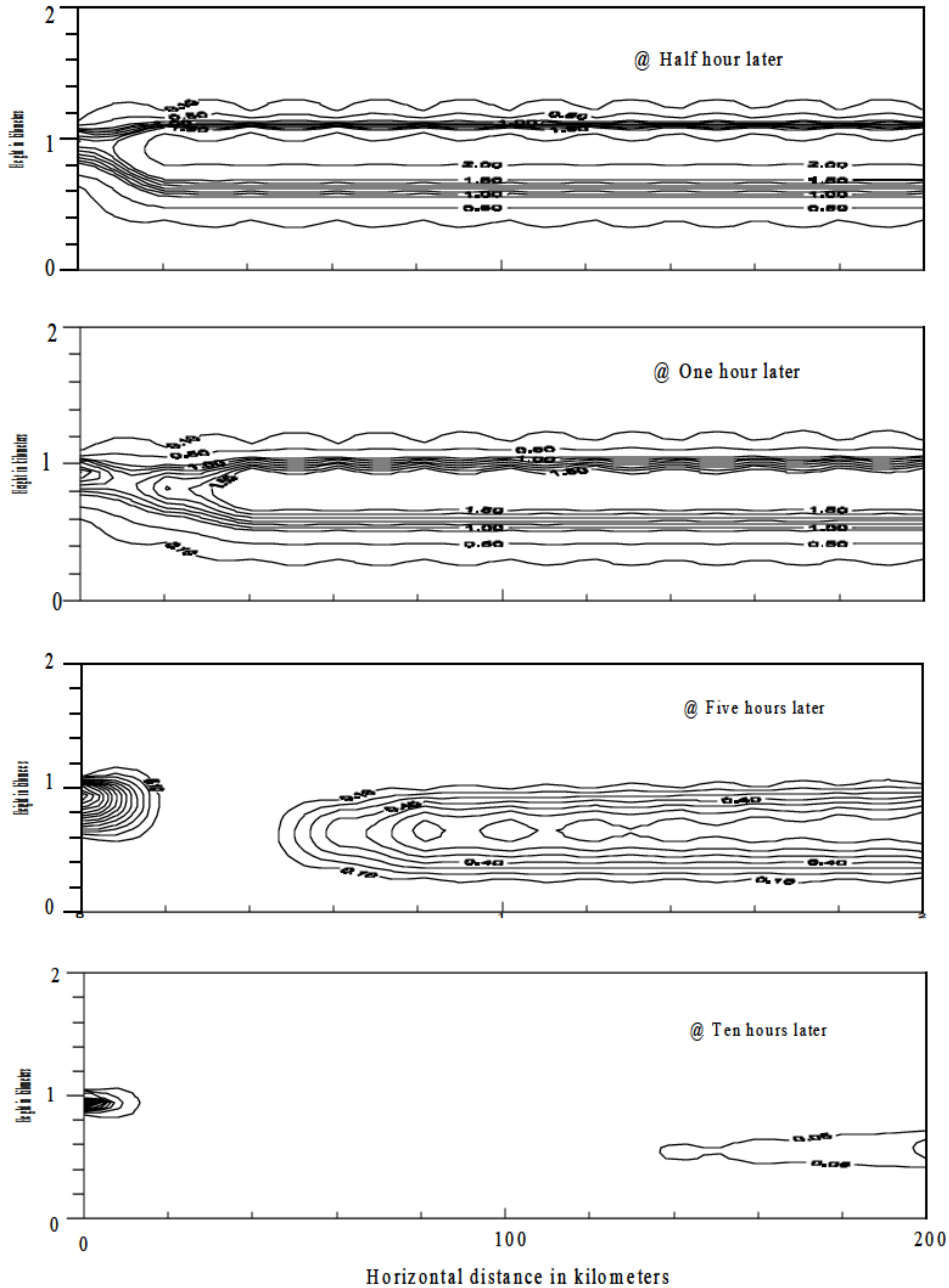

Fig. 3: Predicted Effects of Warm-Air Enrtrainment on the Cloud Stability
(Plotted contours at different time are for liquid water humidity ratio values in grams per kilogram)